# COMPARATIVE STUDY OF FOLIAR ANATOMY OF SOUTH INDIAN SPECIES OF JASMIMUM : I. COSTAL SCLEREIDS AS A NEW TYPE

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ABSTRACT: The comparative study of 22 south Indian species of *Jasminum* has thrown light on the existence of a new category of sclereids which on account of their consistent association always with the costæ and their development from the bundle sheath parenchyma cells due to redifferentiation are designated here as ' costal sclereids ' and in this respect they are contrasted with and distinguished from those of other Oleaceous taxa in which they develop independent of the costæ and hence the conventional term foliar sclereids is reserved for the latter. A positive correlation seems to exist between the mode of development, the resulting types of sclereid on the one hand and the degree of variations shown by the latter on the other. The species of *Jasminum* are classified into 5 groups in accordance with 5 levels of specialization shown by the sclereids. The sclereid data agree though not entirely with DE CANDOLLE's treatment of species under two subgeneric sections and that of CLARKE under one section.

RÉSUMÉ : L'étude comparative de 22 espèces indiennes de *Jasminum* met en lumière l'existence d'une nouvelle catégorie de sclérides. En raison de leur constante association avec les nervures principales et leur développement par redifférenciation des cellules parenchymateuses de la gaine du faisceau, ils sont désignés sous le terme de « sclérides fasciculaires ». Ces caractéres les distinguent de tous ceux des autres taxons d'*Oleaceæ*, qui se développent indépendamment des nervures et auxquels on réserve le terme de sclérides foliaires. Il paraît exister une corrélation entre le mode de développement et les types de sclérides qui en résultent d'une part, et d'autre part le degré de variation des sclérides foliaires. Les espèces de *Jasminum* sont classées en 5 groupes correspondant aux 5 niveaux de spécialisation reconnus dans les sclérides. Ces résultats ne concordent pas totalement avec les classifications proposées par DE CANDOLLE et CLARKE.

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## INTRODUCTION

The occurrence of foliar sclereids in *Ligustrum*, *Linociera*, *Noronhia*, *Notelæa*, *Schrebera*, *Olea*, *Osmanthus fragrans* belonging to *Oleaceæ* is too well known (SOLEREDER, 1908; KRISHNASWAMY, 1942; RAO, 1949; METCALFE & CHALK, 1950; RAO & KULKARNI, 1952; ARZEE, 1953; RAO, 1957; GRIFFITH, 1968; RAO & MANNA, 1975). The different morphological types of sclereids that have been reported so far by the above-mentioned authors have all been observed in the concerned taxa only from the

mesophyll tissues. Furthermore, ontogeny of the sclereids has also been studied in the case of *Olea dioica* and *O. europæa* (RAO & KULKARNI, 1952) and *O. europæa* (ARZEE, 1953). In the year 1951, RAO has reviewed and presented a list of Oleaceous taxa developing sclereids and to this list the genus *Jasminum* is to be included as one more sclereid-bearing taxon in the light of the present work.

As shown in the present work the south Indian species of *Jasminum* differ fundamentally from all the above-mentioned taxa in two important respects. In the first place, the locus of occurrence of the sclereid idioblasts in this genus never occur in the mesophyll but are always encountered in association with the costal regions only (midribs) and secondly all of them belong to two major categories, namely brachysclereids and rectangular sclereids, which appear to be the concomitant of and related to their position. In the present work some interesting sclereid spectrum is reported for the first time in the genus *Jasminum* and the synchronization and the value of sclereid data with respect to the taxonomic grouping of the species proposed by DE CANDOLLE (1846) and CLARKE (1882) is also indicated.

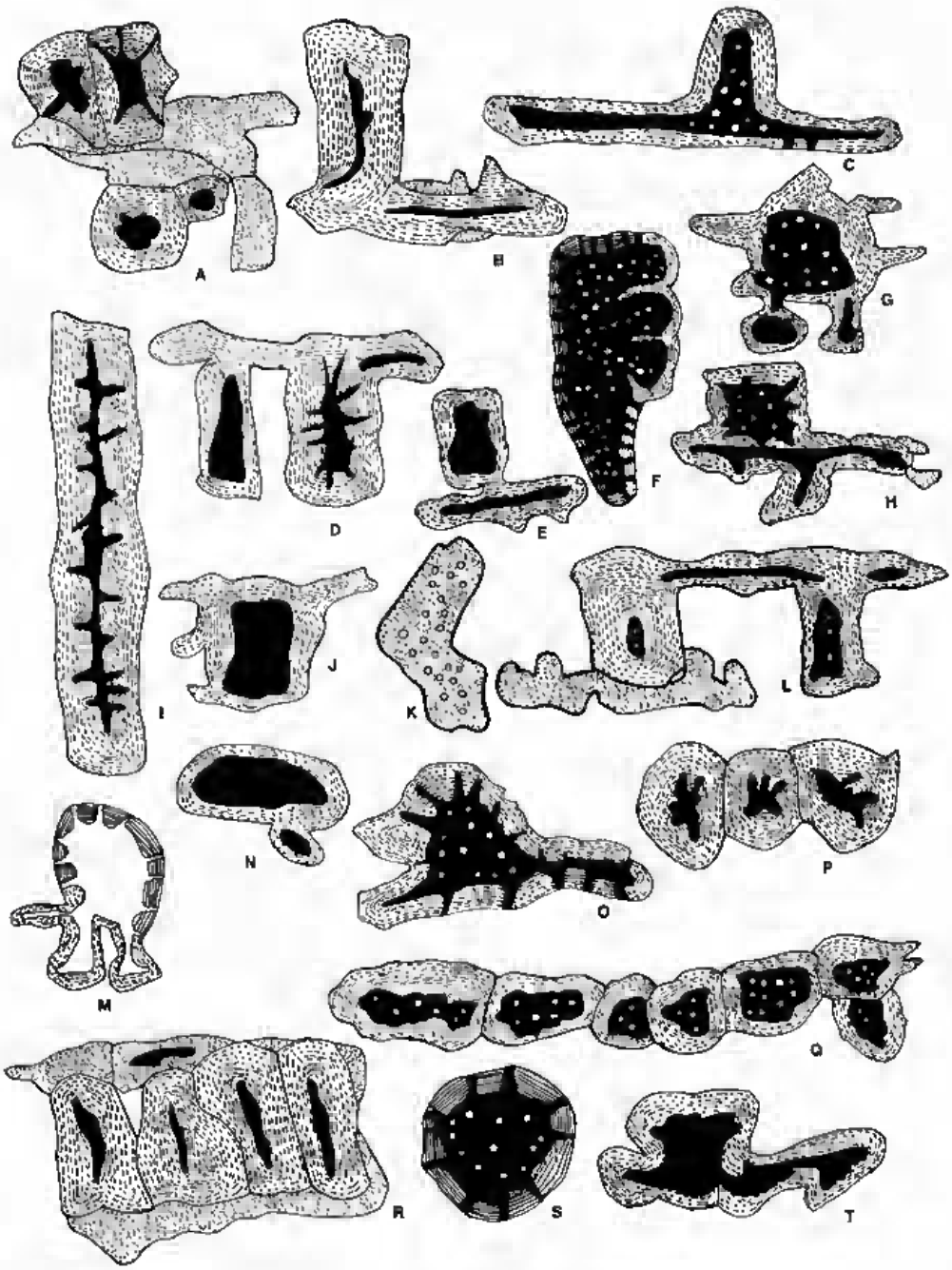
## MATERIALS AND METHODS

The present investigation is based upon the materials of all species except *J. wightii* that are available in the departmental herbarium (except *J. scandens*, MH) and cited here PCM. The cultigen *J. azoricum* was directly collected and used. For the present purpose the mid part of lamina including the midrib has been selected uniformly for all the species. The laminal bits were revived in the case of siccate materials by boiling them up to simmering stage in water containing 1 % solution of ' det ' (commercial soap powder) and 50 % glycerol. This was followed by a thorough washing in water (GOVINDARAJALU & PARAMESWARAN, 1967). Clearing of the laminal tissues thus revived was accomplished according to the schedule recommended by FOSTER (1950). After clearing the samples were thoroughly washed in water, dehydrated and stained with safranin following the customary method. The citation of the materials is given in the list prepared according to DE CANDOLLE system (1846).

## OBSERVATIONS

### GENERAL CHARACTERISTICS — Pl. 1

Broadly speaking, brachysclereids and rectangular sclereids are observed to be the only two major fundamental types present in the abaxial sides of the costal regions, but the frequency of their distribution varies with different taxa as shown below. Between these two kinds of sclereids, the exclusive occurrence of either brachysclereids or rectangular sclereids with their respective modifications seems to be less common when compared with the combined occurrence of both brachysclereids and rectangular sclereids in varying combination and proportion in a given taxon. Generally, in all the taxa, the sclereids occur in abundance in the proximal regions of the leaves and gradually decrease towards the distal regions. Sometimes




Pl. 1. — **A-H, J-O, R, Jasminum pubescens**; **I, J. malabaricum,** rectangular sclereids; **P & Q, J. auriculatum**; **S, J. azoricum**; **T, J. rottlerianum**. (For explanation, see text; **all** × 760).

| Name of the species | Collector | Locality |
|---|---|---|
| Sect. **Unifoliatæ** : | | |
| 1. *Jasminum angustifolium* Vahl. | Govindarajalu 3647 | Kattupakkam, Chinglepet Dt. |
| 2. *J. arborescens* Roxb. . . . . | Barber 1335 | Sumonbadi, Ganjam Dt. |
| 3. *J. brevilobum* A.DC. . . . . | Fyson 29194 | Ooty |
| 4. *J. cordifolium* Wall. . . . . | Fyson 3377 | Ooty |
| 5. *J. malabaricum* Wt. . . . . | Janaki s.n. | Tellicherry, Kerala state |
| 6. *J. pubescens* Willd. . . . . | Fyson 2730 | Haduvattam, Ooty Dt. |
| 7. *J. rigidum* Zenk. . . . . | Govindarajalu 3660 | Kattupakkam, Chinglepet Dt. |
| 8. *J. ritchiei* Clarke[1] . . . . . | Ekambaram s.n. | Anantagiri |
| 9. *J. rottlerianum* Wall. . . . . | Mayurnathan s.n. | Coonoor, Ooty Dt. |
| 10. *J. roxburghianum* Wall. . . . | Govindarajalu 3680 | Kattupakkam, Chinglepet Dt. |
| 11. *J. sambac* Ait. . . . . | Swamy & Harikrishnan 532 | Vedanthangal, Chinglepet Dt. |
| 12. *J. scandens* Vahl . . . . . | Balakrishnan & Henry 11899 | Bastar, Madhya Pradesh |
| 13. *J. sessiliflorum* Vahl . . . . | Swamy & Harikrishnan 502 | Vedanthangal, Chinglepet Dt. |
| 14. *J. trichotomum* Heyne . . . . | Govindarajalu 3776 | Nagari Hills, A.P. |
| Sect. **Trifoliatæ** : | | |
| 15. *J. auriculatum* Vahl . . . . . | Swamy & al. 352 | Vandalur, Chinglepet Dt. |
| 16. *J. azoricum* L. . . . . | Karunakaran s.n. | Presidency College, Madras |
| 17. *J. calophyllum* Wall . . . . . | Govindarajalu & al. 2278 | Kodamadi, Tinnevely Dt. |
| 18. *J. flexile* Vahl . . . . . | Kamath 141 | Koiltheri, Kerala State |
| 19. *J. wightii* Clarke . . . . . | not investigated | |
| Sect. **Alternifolia** : | | |
| 20. *J. humile* L. . . . . | Fyson 6841 | Binsen |
| Sect. **Pinnatifolia** : | | |
| 21. *J. bignoniaceum* Wall. . . . . | Fyson 4037 | Kodaikanal, Madurai Dt. |
| 22. *J. grandiflorum* Wall. . . . . | Fyson 2191 | Ammanayakanur |

1. Not mentioned by De Candolle (1846) since this taxon is subsequently reported by Clarke (1882). On the basis of the type of sclereid and that of simple leaves included here under sect. *Unifoliatæ*.

a tendency is also witnessed for the development of sclereids in an overlapping manner (fig. A, R) and for the occurrence of two different forms adjacently (fig. L).

The costal sclereids occur either in a single continuous row as in *J. auriculatum* (fig. P, Q), *J. brevilobum*, *J. flexile*, *J. roxburghianum*, or in two continuous rows as in *J. sambac*, or in isolated clusters, each cluster containing 2 or 3 sclereids, as in *J. angustifolium*, *J. arborescens*, *J. calo-*

*phyllum, J. rigidum, J. ritchiei, J. roxburghianum* or solitary as in *J. azoricum, J. cordifolium, J. malabaricum, J. pubescens, J. rottlerianum, J. sessiliflorum* and *J. trichotomum.* It is interesting to observe that more than one pattern of distribution of sclereids is present in *J. roxburghianum* both in the form of a single continuous row and in clusters. For the purpose of convenience, the species of *Jasminum* are considered with respect to the types of sclereids and their extent of occurrence under the following five categories.

CATEGORY I : The species coming under this category develop brachysclereids which are isodiametric with or without ramification. The thickness of the walls varies not only among the species coming under this category but even within the same species, sclereids in different loci exhibit variations in this respect. Likewise variation is also encountered with respect to the presence or absence of pittings (fig. Q) or absence of wall pittings (fig. P, T). These sclereids generally occur in a single continuous row (fig. Q) of or more than one row. On the whole the variations shown by this type of sclereids are however within certain narrow limits. The species that share the above-mentioned characteristics of this kind of sclereids are *J. auriculatum, J. calophyllum, J. rottlerianum* and *J. sambac.* As far as the occurrence of pit canals in the cell walls is concerned they are either not developed as in *J. auriculatum* (fig. P, Q) and *J. calophyllum* or only occasionally present despite the thickness of the cell walls as in *J. rottlerianum* and *J. sambac.*

CATEGORY II : *Jasminum malabaricum* and *J. scandens* are the only two species that develop rectangular sclereids and thus represent the second category. But for the position with respect to the costæ, these sclereids may as well be designated either as palosclereids or macrosclereids. The sclereids are 3-4 times longer than broad besides other well known structural characteristics (fig. I). Since no specific terminology is available for designating this type of sclereid they are designated here as rectangular sclereids, on the basis of their length and width relationships. However these sclereids are found to be the least modified.

The other two categories of sclereid are recognized primarily on the basis of the combined occurrence of the above-mentioned two types (brachysclereids and rectangular sclereids). The combination of these two kinds of sclereids is such that in one group of species both brachysclereids and rectangular sclereids occur in equal proportions though not conforming to any particular pattern while in another group of species there is a lesser quantum of rectangular sclereids when compared with the quantity of brachysclereids. Based upon this criterion namely equal representation of both types on the one hand and their unequal representation on the other the remaining species are classified as follows:

CATEGORY III : In *Jasminum azoricum* (fig. S), *J. arborescens, J. brevilobum, J. flexile, J. pubescens* and *J. roxburghianum*, both brachysclereids and rectangular sclereids are either equally or more or less equally well

represented. As mentioned earlier, the rectangular sclereids are almost free from showing any modifications whereas it is only the brachysclereids which reflect a broad spectrum of variation particularly with regard to their size and configurations (fig. A-H, I-O, R). In this respect *J. pubescens* which is a species growing at higher altitudes is particularly remarkable and hence deserve special mention in that bizarre sclereid form are revealed by this single taxon (fig. A-H, J-O, R) and not in any other taxon either within or outside this category of species. As a result of the present analysis of the sclereid situation in this species the following modifications of brachysclereids have been observed: 1°) One group of sclereids is elongated with prolongations unilaterally (fig. N) or multilaterally (fig. G, H, J, M, O).—2°) T-shaped with a short (fig. C) or long foot.—3°) Sclereids having one of the arms shorter than the other thus becoming an asymmetrical 'T' type which ultimately leads to the development of L-shaped sclereid due to the suppression of non development of one of the arms (fig. B); however it is observed that the surfaces of the arms appear to be quite uneven and convoluted.—4°) The elongated branched type of sclereids are lobed or convoluted in such a way as to appear like a caterpillar or a worm and they are usually not having a lumen (fig. K, L).—5°) Sometimes the elongated sclereids are juxtaposed and appear to unite with each other by the superimposition of the isodiametric sclereids at right angles to the former thus presenting a ladder-like arrangement (fig. R).—6°) Isodiametric brachysclereids may become somewhat wedge-shaped (fig. F) or variously trigonous and densely pitted (fig. F).—7°) In certain loci of the costa nests of brachysclereids with little modifications occur in an overlapping manner (fig. A). Despite the above mentioned morphological variations of the sclereids observed in *J. pubescens* all of them appear to indicate a continuum of variations and thus they seem to be interrelated to each other due to the successive superimposition of just one or two additional characteristics upon the basic brachysclereid type. Thus a multiplicity of sclereid types are observed in *J. pubescens* alone (fig. A-H, J-O, R).

CATEGORY IV : *Jasminum angustifolium*, *J. cordifolium*, *J. rigidum*, *J. ritchiei*, *J. sessiliflorum* and *J. trichotomum* are all characterized by the combined occurrence of both brachysclereids and rectangular sclereids as in the previously mentioned category of species but there is just a slight tendency for the development of rectangular sclereids by the said species and this tendency causes the occasional presence of rectangular sclereids but at the same time a relatively wider representation of brachysclereids is witnessed. Irrespective of the thickness of the cell walls it is observed that the species possess either simple pit canals (*J. angustifolium*, *J. rigidum*, *J. trichotomum*) or no pit canals as in *J. cordifolium*, *J. ritchiei* and *J. sessiliflorum*.

CATEGORY V : Of all the south Indian species of *Jasminum* examined, *J. bignoniaceum*, *J. grandiflorum* and *J. humile* are the only three species

that stand out as an exceptional group in totally not developing any one of the above-mentioned sclereid types nor their combinations. Although *J. humile* has been recorded from south India, material from Himalayas has been examined.

## DISCUSSION AND CONCLUSIONS

As mentioned earlier it is known that seven taxa belonging to *Oleaceæ* develop foliar sclereids (SOLEREDER, 1908; KRISHNASWAMY, 1942; METCALFE & CHALK, 1950; RAO & KULKARNI, 1952; ARZEE, 1953; GRIFFITH, 1968) and in this respect no report is available on the development of sclereids in species of *Jasminum*. Out of these taxa known for their sclereid content it is interesting to know that in almost all species of *Linociera* sclereids (" sclerenchymatous elements showing varied types of differentiation " *sensu* SOLEREDER, 1908) have been mentioned. However, it may be pointed out that in all the taxa except *Jasminum* the different types of sclereids have been reported only from different parts of the mesophyll tissues of the lamina which are either in the palisade or diffuse or almost diffuse terminal with respect to the veins (RAO, 1951), and not from the costal regions which occurrence appears to be in the first place a very characteristic unique feature of the taxon under consideration. Secondly the sclereids that are now reported in the genus *Jasminum* belong to altogether different morphological categories not encountered so far in the rest of the Oleaceous taxa, which on the other hand are characterized by only ophiuroid, fusiform or lobed, vesicular, sclereids, sphærosclereids, osteosclereids, filiform sclereids, astrosclereids, crystalliferous sclereids, T-shaped root-like and variously branched sclereids. In other words, in all the south Indian species of *Jasminum*, only brachysclereids or rectangular sclereids either alone or in varying combinations and proportions of both are observed. Thus the south Indian species of *Jasminum* appear to be interesting and unique, not only in terms of sclereid types which are hitherto unknown in *Oleaceæ* as a whole, but also from the standpoint of their unusual occurrence in regions of costal proximity only. Although it is true that broadly speaking the sclereids that are present in the lamina independent of the costæ are designated as foliar sclereids, those of south Indian species of *Jasminum* should be differentiated from the latter as a new subtype under the general category of foliar sclereids and labelled as " *costal sclereids* ", particularly in view of their constant and consistent approximation with main costæ and nowhere else. Furthermore this procedure is also supported by the fact that in the first place the ontogeny of the costal sclereids, as occurring in *Jasminum*, seems to be different from that of the sclereids of other taxa since in the former they appear to have developed from the existing bundle sheath cells of the costæ as a result of redifferentiation, while in the latter from separate initials of their own. Secondly, on comparing the types of sclereids in *Jasminum* on the one hand with those of other sclereid bearing taxa of the *Oleaceæ*

on the other, those of the former happen to be brachysclereids and rectangular sclereids showing at the same time variation to a lesser extent whereas of the latter altogether belong to several different morphological types (*vide supra*). Thus the costal sclereids of *Jasminum* become different from the foliar or otherwise known as non-costal sclereid types of other Oleaceous taxa, both in respect of their ontogeny and position.

According to DE BARY (1884) the occurrence of sclereids associated with the vascular bundles in many angiospermous taxa has been stated to be rare. On the contrary, this situation is not so rare as reported by De BARY (1884), particularly if the findings of the present study and of those in *Salvadoraceæ* by GOVINOARAJALU & PARAMESWARAN (1967) are taken into consideration. The reasons for such an earlier assumption (DE BARY, 1884) and the paucity of any report in this respect is perhaps due not to the non-existence of such a phenomenon elsewhere, but to the fact that the students of sclereid morphology have hitherto been focussing their attention and searching for the sclereids frequently from laminal parts only thereby overlooking the costal areas.

It is now well known that there are two distinct modes of development of the sclereids (ESAU, 1972). One mode of development takes place from the individualized sclereid initials themselves which in turn, as has been demonstrated by authors of sclereid ontogeny, are supposed to be endowed with certain special cytological characteristics such as the presence of a conspicuous nucleus, dense cytoplasm and with or without vacuoles (RAO, 1958), and the sclereids that are ultimately developing out of these initials naturally undergo profound structural and morphological changes thereby exhibiting their unlimited potentialities for enormous variations which are sometimes even coupled with aggressiveness during the course of development (FOSTER, 1945, 1947, 1955; ARZEE, 1953; RAO, 1957; GOVINDARAJALU, 1962). This kind of development of the sclereids directly from their respective initials may be considered for the present purpose as the " direct development ". On the other hand, in the second mode of sclereid ontogeny, namely the development of sclereids as a result of redifferentiation of some of the existing living cells may be considered as the " indirect development ". The sclereids of indirect development appear to be generally endowed with a limited capacity for variation as judged in terms of their structural variation and modification (GOVINDARAJALU & PARAMESWARAN, 1967). In the light of this general situation a working hypothesis may be suggested that there are two different and contrasting modes of development which lead accordingly to the formation of two broad categories of sclereids each one of them exhibiting its own line of structural specialization. In other words, it may be stated that the sclereids that appear to be less variable and polymorphic are generally the products of indirect development as in the case of macrosclereids of leguminous testa (ZIMMERMAN, 1936), agglomerate sclereids in *Salvadora* and *Dobera* (GOVINDARAJALU & PARAMESWARAN, 1967) and the sclereids of *Jasminum* species while those that are highly variable, abundantly polymorphic and becoming even aggressive and gigantic in

size seem to be the derivative of direct development. Thus ultimately the resulting form of sclereids which are polymorphic or otherwise in a given example seems to be related in a way to the direct or indirect type of their development.

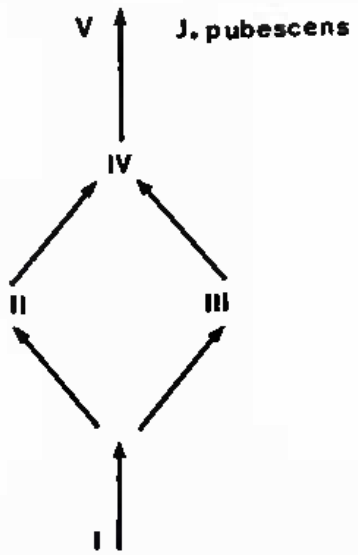



Fig. 2. — Schematic representation showing the probable trends of specialization of sclereids: Level I, taxa without sclereids; II, taxa with rectangular sclereids only; III, taxa with brachysclereids only; IV, taxa with the predominance of brachysclereids; V, taxa with equal or more or less equal representation of both brachysclereids and rectangular sclereids; J. pubescens showing a minor trend of VIth level. (For further explanation, see text).

If the occurrence of sclereids in any taxon is supposed to be indicative of its advanced condition, all the species of *Jasminum* except *J. bignoniaceum*, *J. grandiflorum* and *J. humile* may be considered as more advanced than the latter since they do not develop any kind of sclereids at all. However, taking all the south Indian species of *Jasminum* into consideration, they may be grouped into five major categories based upon the presence or absence of sclereids, their level of specialization, mode of occurrence (single unit or in varying combination) and their tendency for diversification. In the light of this it is possible to arrange the taxa in the order of their increasing specialization (fig. 2). The first level is represented by *J. bignoniaceum*, *J. grandiflorum* and *J. humile* which are characterized by the total absence of sclereids thus becoming the basic stock from which the remaining levels may be derived. The second level represents a condition in which there is a development of rectangular sclereids only as in *J. malabaricum* and *J. scandens* and they do not exhibit any significant morphological and structural variations. *J. auriculatum*, *J. calophyllum*, *J. rottlerianum* and *J. sambac* exemplify a third level in which brachysclereids alone are developed but at the same time showing

a tendency for variation in forms to a certain limited extent when compared with the species of the second level. Thus the second and third level seems to suggest two independent lines of parallel development out of the basic stock in that each one of them is characterized by the development of either rectangular sclereids or brachysclereids. The fourth level of specialization which is witnessed in *J. angustifolium*, *J. cordifolium*, *J. rigidum*, *J. ritchiei*, *J. sessiliflorum* and *J. trichotomum* is indicated by the combined occurrence of both brachysclereids and rectangular sclereids although the development of the latter appears to be subdued when compared with that of the former thereby resulting in the formation of more of the brachysclereids than of the rectangular sclereids. *Jasminum azoricum*, *J. arborescens*, *J. brevilobum*, *J. flexile*, *J. pubescens* and *J. roxburghianum* indicate the fifth level of specialization in so far as the equal or more or less equal development of both brachysclereids and rectangular sclereids is concerned. Of all the species examined belonging to the fifth level it is only *J. pubescens* that reveals relatively greater variation of the brachysclereids when compared with other species and in this respect this particular taxon is considered as the most specialized one that seems to have developed as an offshoot of the Vth level (fig. 2) since all other species within this group or outside this group develop either one or two kinds of least modified sclereids or none at all. Taking into consideration all the above mentioned situation of the sclereids, it may be stated without implying any phylogenetic speculation that there appears to be an expression of a particular type of sclereid at every successive level due to the superimposition of just one or a few character or characteristics upon the preceding type thereby demonstrating a natural continuum of variation.

In conclusion, it may be said that all the south Indian species of *Jasminum* are classified into five major groups based upon five different levels of specialization as mentioned above. The non sclereid-bearing taxa include the Ist group (basic stock) out of which there is a dichotomous line of development, one line giving rise to IInd group characterized by the rectangular sclereids only while another line to IIIrd group possessing brachysclereids only. The next two higher IVth and Vth groups of species represent the combination of both rectangular and brachysclereids and in this respect in the IVth group the brachysclereids are more predominant than the rectangular sclereids while in the Vth group there is the development of both brachysclereids and rectangular sclereids to the same or more or less to the same extent. A minor trend of specialization is displayed by only one particular species (*J. pubescens*) belonging to the Vth group (fig. 2).

Although the sclereids situation in south Indian species of *Jasminum* does not reflect a perfect agreement with respect to taxonomic classification yet as far as the system of De Candolle (1846) is concerned the section *Alternifolia* to which *J. humile* belongs and the section *Pinnatifolia* to which *J. bignoniaceum* and *J. grandifolium* belong are characterized by the total absence of sclereids. Thus, it is interesting to observe that out of 4 sections recognized by De Candolle (1846) the last two sections

(sect. *Alternifolia* and *Pinnatifolia*) appear to be natural in respect of the total absence of sclereids. Likewise the comparison of the sclereid data with the classification of Indian species of *Jasminum* by C. B. CLARKE (1882) does not reveal any cogent picture nor synchronization with the taxonomic grouping except the species of one particular group having simple leaves and glabrous calyx (*sensu* CLARKE, 1882) shows perfect agreement by way of developing in combination more of brachysclereids and less of rectangular sclereids.

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